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Spray-coated CZTS Nanoparticles in Water for Environmentally-friendly, Inexpensive Solar Cell Absorber Material

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The kesterite material, Cu_2ZnSnS_4 (CZTS), is very promising as absorber material in future thin film solar cells. The elements are abundant, the material has a high absorption coefficient, and it is non-toxic. These properties make CZTS a potential candidate also for large-scale applications. Here, solution processing allows for comparatively fast and inexpensive fabrication and the power conversion efficiency is also relatively high. The current challenges are, (1) that the nanoparticles do not sinter during annealing, and (2) that grain boundaries and defects are believed to be a site for recombination that limits the efficiency. Annealing in vacuum, nitrogen and/or a diluted hydrogen atmosphere facilitates grain growth and improves the electronic properties.

In this work, nanocrystals of CZTS with a targeted Cu-poor/Zn-rich composition are synthesized through a hot-injection method with diethylene glycol as the solvent, which makes them dispersible in water. The nanocrystal inks are deposited through spray coating, and annealed in a vacuum furnace using a graphite box with sulfur. The surface morphology and thus grain growth are studied for various annealing conditions.

The films are characterized with scanning electron microscopy (SEM), and an example before and after annealing is displayed in Fig. 1 (a) and (b), respectively. Compositional changes are monitored by energy dispersive X-ray spectroscopy (EDX) and the crystallinity by X-ray diffraction (XRD).

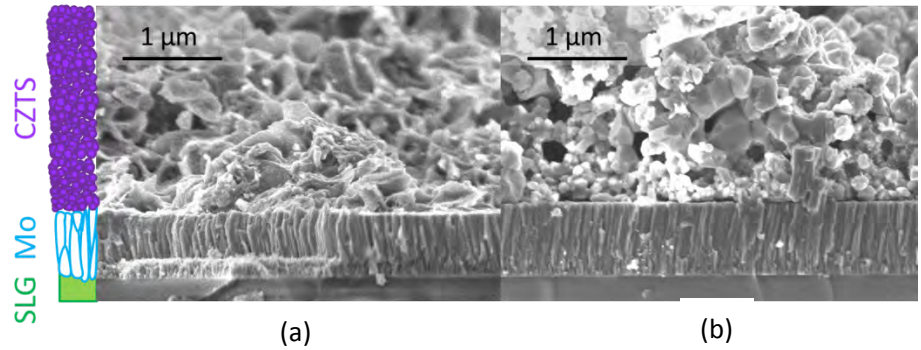

Fig. 1 SEM image of cross-section of spray-coated CZTS film after (a) pre-annealing at 200˚C, and (b) annealing in nitrogen atmosphere at 550˚C, where grain growth is visible.